Project: BiG>East

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Biogas Case Studies in Slovenia

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Matjaž Grmek, Ivo Blaznik

ApE d.o.o.

Litijska 45, Ljubljana

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Executive summary

of the two chosen case studies:

Biogas plant 1: Klinja vas

A **pigs breeding facility in Klinja vas** near Kočevje it was chosen as a first case study. Farme Ihan company, which is the biggest pigs raising company in Slovenia and was one of the pioneers in producing biogas in Slovenia. It is located in the southern part of Slovenia - Dolenjska region. It is less industrialised and of prevalent agricultural nature and with a good biomass potential. The most suitable or the first to be addressed it seems to be the stockbreeding since it is also more appropriate from the heat usage point of view. Base on these premises suitable site was selected.

It used to sell around 25.000 piglets a year. The farm is now in reconstruction and the planned year capacity is approximately doubled. Estimated manure available as a feedstock input is 80t per day. Water from dewatering of digestate is used to reach the desired 8% dry matter content of pig slurry. Feedstock used could be also green biomass and waste food in that case the capacity of the biogas plant could be more than doubled to 500 kWe.

The planned digestion process of the plant is a mezzophilic at around 36^{o}C and is based primarily on pigs slurry. The total amount of yearly biogas production is approx. 700.000 m^3 (approx. installed capacity 200 kWe). The biogas is utilised in a gas engine (CHP unit) for the production of electricity for sale to the grid (14 GWh/year) and for heat production (16 GWh/year). The heat is mainly used for the process (approximately 55%) and no external heat sale is foreseen. The existent farm size is big enough for the proposed plant.

The table below summarises the basic data and financial assumptions applied for the needs of the assessment and calculation of the economic forecast and the main results. The BiG East calculation model was used. It should be noted that the results generated by the model should be only used as indicative and can be subjected to change.

Technical data	
Feedstock	29.000/a
Biogas production	700.000 m^3/a
Electricity sold	14 Gh/a
Fertilizer	24.400 t/a
Compost	2760 t/a
Financial structure	
Investment Costs	820,000 €
Electricity Price	0,0155 €/kWh
Nominal Heat Price	0.01 €/kWh
Results	
Earning before Interest	148.000 €
Internal Return Rate (IRR)	8%
Capital Cost	59.100 €/a
Total Earnings	89.000 €/a

Biogas plant 2: Biotechnical Centre Naklo

For the second case Biotechnical centre Naklo was chosen. It is located near the main town Kranj. Biotechnical centre Naklo comprises education and eco-farming. The biomass available is both cattle manure and green biomass that originates on spot. The quantities are quite small though. It was estimated that farm on its own is able to produce enough input for about 100 kW biogas CHP production unit and double that if input from the surroundings is taken into account. That is however not the case as this would endanger the eco status of the BC Naklo farm.

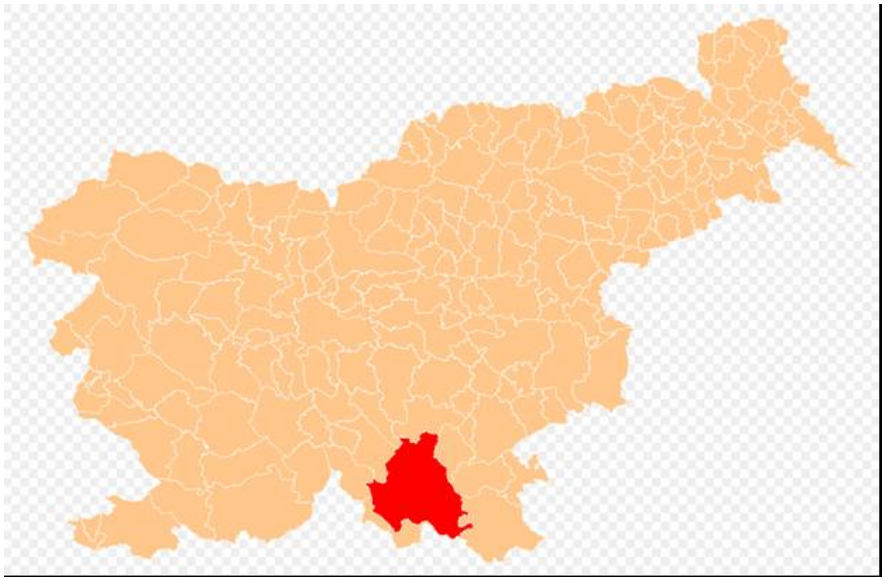
The planned digestion process of the plant is a mezzophilic at around 36°C and is based on cattle manure and biomass. The total amount of yearly biogas production is approx. 400.000 m^3 (approx. installed capacity 100 kWe). The biogas is utilised in a gas engine (CHP unit) for the production of electricity for sale to the grid (850 MWh/year) and for heat production (1 GWh/year). The heat is mainly used for the process (approximately 55%) and no external heat sale is foreseen. The existent farm size is big enough for the proposed plant.

The table below summarises the basic data and financial assumptions applied for the needs of the assessment and calculation of the economic forecast and the main results. The BiG East calculation model was used. It should be noted that the results generated by the model should be only used as indicative and can be subjected to change.

Technical data	
Feedstock	4.600 t/a
Biogas production	400.000 m^3/a
Electricity sold	850 Mh/a
Fertilizer	3.500 t/a
Compost	700 t/a
Financial structure	
Investment Costs	770,000 €
Electricity Price	0,0165 €/kWh
Nominal Heat Price	0.01 €/kWh
Results	
Earning before Interest	104.300 €
Internal Return Rate (IRR)	7%
Capital Cost	67.600 €/a
Total Earnings	36.800 €/a

1. Biogas Case Study: Klinja vas

Dolenjska region is the south-eastern part of Slovenia. The region is less industrialised, it is of prevalent agricultural nature and it has a good biomass potential. Municipality Kočevje is the biggest in Slovenia and almost 90% of its territory is covered with forest and it is one of the best preserved natural areas in Slovenia with virgin forest, bears, and wolves. It is therefore logically that they use biomass for district heating in the town of Kočevje. In the past we have had good cooperation with them when preparing feasibility study for it. Therefore we were keen on dealing with a new RES project there as we thought they would embrace the idea.



Slovenian and its municipalities, Kočevje is in the largest

The entire region faces a considerable problem in the agricultural sector, mainly due to farms with widely scattered plots, and in some parts also due to the karst terrain which prevents the introduction of modern farming methods. In terms of agriculture, the region is characterised by mixed farming with a slight bias towards dairy and beef cattle farming.

One of the most suitable areas for biogas production, or the first to be addressed, it seems to be the stockbreeding since it is also more appropriate from the heat usage point of view. After the region and municipality was selected we looked for a suitable site. We found out there is a pigs breeding facility in Klinja vas near Kočevje, where they use to breed 25.000 piglets annually. The farm was bought by Farme Ihan and is now in reconstruction with the planned capacity is 50.000 piglets per year. Farme Ihan company is or at least used to be the biggest pigs raising company in Slovenia and was one of the pioneers in producing biogas in Slovenia. In 2005 the farm founded its own company FI-EKO for the purposes of the green electricity production (from anaerobic purifying of the pigs manure) and they acquired also the status of what was at the time the so called qualified electricity producer and now they obtained the declaration (for the electricity production from RES) on the plant.

Farm in Klinja vas

Feedstok in this case is pig manure from the farm that originates on the same spot hence no particular logistic study is necessary. The planned biogas plant shall be operated prevalently with the input material of liquid manure from pigs. The quantity of pig manure estimated is around 80 m3 per day. In case of interest also some green biomass from the neighbouring farms could be used, which would improve the biogas production and hence the economic viability of the plant. The economic aspect is here not the only one though, what is also important is the cleaning of the waste water and manure use. To use the digestate as a fertilizer – estimated production of 40 t per day - should not be a problem since the farm is lying in the middle of the fields and there is also enough room for the digestate container. Since FI-EKO has already some experience with using co-substrates at the Ihan biogas plant e.g. old bread, this possibility is not entirely to exclude.

Ortophoto of the Farm Klinja vas

Also what electricity grid is concerned the location is favourable enough. The grid (20kV) is distanced about 200m from the farm, and the spot there is enough room for the electric transformer. The road access is good. Distance of the plant from the settlement is shown in the picture above.

1.1. Basic plant design

Biomass and biogas potential

Manure used for digestion is all produced on spot. The most probable plant type is a co-digestion one which besides the manure could make use also of green biomass and/or food waste from Kočevje. The final execution depends on the final arrangements, which were not done yet.

The gas potential is calculated by means of the BiG East calculation model. Based on the estimations of the feedstock availability in the area the following biogas production calculation is shown below.

Klinja vas			**Biogas production**
Input	t /a	% DM	m^3 /a
Pig slurry	33,000	8	700.000

The amount of manure used in the calculation is based on the Farme Ihan estimations and no co-substrates were taken into account for the calculation. Just to be on the safe side of the equation as the use of co-substrates would only benefit to the economic aspect of the plant. The biogas produced by digestion shall be utilised in a combined heat and power unit and the electricity generated sold (feed-in) and supplied into the electricity grid.

Utilisation of the biogas

The total amount of biogas production is approx. 700.000 m^3 (installed capacity around 200kWe) if only manure is used. In this case the biogas would be utilised in a CHP unit with gas engine and generator for the production of electricity for sale into the grid (feed-in tariffs) and for production of heat, which would be consumed on spot. The heat is mainly used for the process and heating of the premises. No external heat use is foreseen. The following energy production can be expected:

Energy production			
Biogas production engine capacity	4.176.000 kWh/a 191 kWe	at	6,00 kWh/m3 biogas
Utilisation			
Electricity production Total electricity production	1.670.000 kWh/a 1.587.000 kWh/a	at and	40% efficiency 5% of the time out
Heat production Used in the process For other use	1.921.000 kWh/a 1.044.000 kWh/a 877.000 kWh/a	at at	46% efficiency 38° C

Calculated electricity production of approx. 1.590 MWh per year can be expected. Smaller part of the electricity produced is used for the plant operation (pumps, mixers, blowers etc.). This is estimated to approx. 95 MWh (equal to approx. 6% of the total electricity production). Which means approx. 1.500 MWh is left for the sale to the grid. It is expected that the engine is out of operation for servicing in approx. 5% of the time of the year. During service the gas is burned in a boiler for producing heat for the plant and possible surplus gas is flared off.

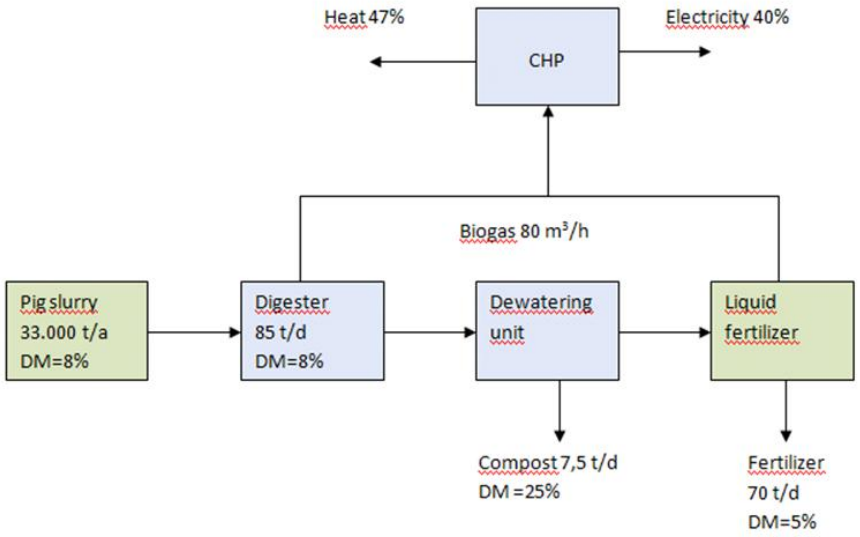
Biogas Digestate Utilisation

According to the nitrate directive the raw manure produced on farm and used for biogas production would require approx. 3.060 ha. The requirement after digestion and separation will be lower because nitrogen is removed in the fibre fraction. The land requirement for using the liquid fraction as a fertilizer will be approx. 2.400 ha meaning a saving of approx. 600 ha spreading area. This means the reduced pressure on land locally and lower costs for transport and spreading. The solid fertiliser (the fibre fraction) could be sold as solid fertiliser.

Flow chart

The mass balance of the biogas plant Klinja vas is quite simple. It is assumed that the digestate is separated in a liquid fraction and a solid one in order to reach higher utilisation of the nutrients.

The feedstock input taken into account is just manure. However it could be also green biomass (grass and/or corn silage) and e.g. food waste.



1.2. Technology Specifications

The feedstock planned is mainly manure regarded as suitable for mezzophilic digestion at 36°C and a retention time in the primary digester of approx. 30 days.

Overall plant set up

The manure is produced on the farm itself. This means transport and logistic required are minimal and are mainly related to the out taking of the digestate. The plant is provided with the reception tank, prime and secondary digester and final storage tank. By an estimated retention time of approx. 30 days in the primary digesters the volume of the primary digesters will be approx. 500 m^3. For easy mixing of the feedstock and to save space digesters are foreseen as concrete insulated silos with internal heating pipes system and that they are provided with top mounted mixers. On the other hand secondary digesters can be made from a non insulated concrete tanks provided with a double membrane. The digestate is to be used as fertiliser and supplied/available to neighbouring farms and for farm own purposes. A buffer tank of around 1000 m^3 is included on the site for the purpose.

1.3. Economical specifications

Investment

Based on the plant design (inputs and outputs) and technological solution which are described above the estimated costs are shown below. Biogas project tend to be financially demanding. In case of the project Klinja vas it was taken into account that future operator and owner of the plant has substantial experience gathered on the subject and therefore able to lower some costs. Based on the above mentioned facilities and plant design the investments costs for such a plant are as follows:

Investment Cost: Project No 1 Klinja vas	**Euro**
Planning, engineering, commissioning etc	70,000
Equipment, machinery	200,000
CHP engine etc.	175,000
Construction, Buildings	250,000
Electrical equipment	60,000
Other costs	65,000
Total	**820,000**

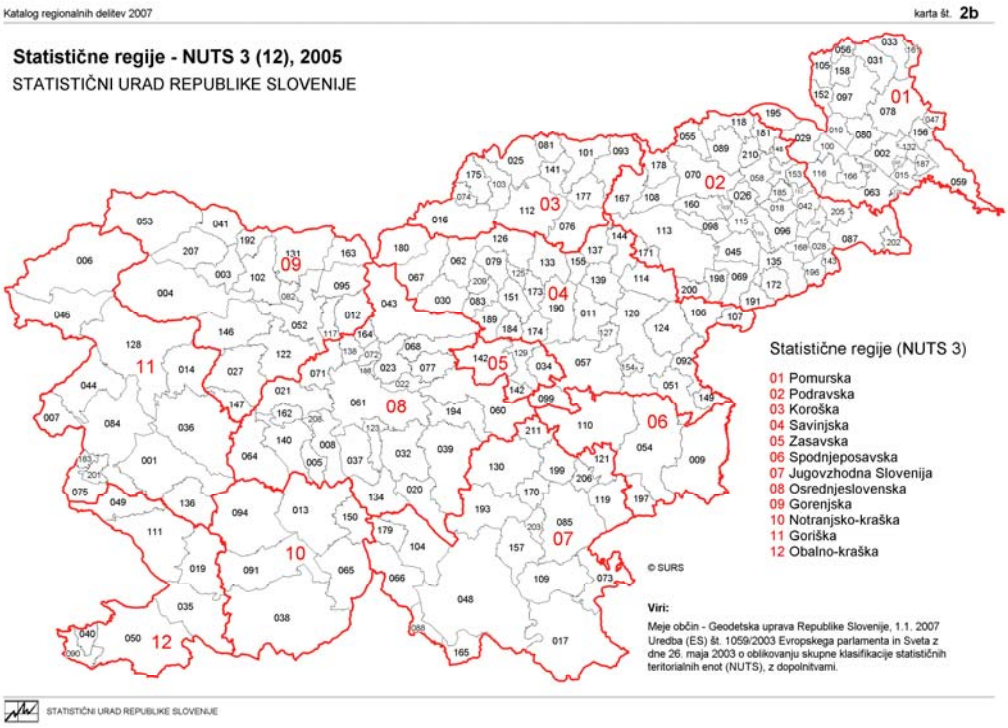
Profit and Loss

For the assessment and the basic economic calculation the BiG East calculation model was used. Thus getting the preliminary estimation of costs, plant size, technical outline etc. The calculation model as well as the guidelines for its utilisation are freely available to download at www.big-east.eu. The main results obtained for the show case Klinja vas in summarised way is given in the table below:

Profit and Loss: Show Case No1 Klinja vas	**Euro/a**
Economic Yield from Plant Operation	
Yield from electricity sale	241,000
Plant working costs	
General Busines Cost	102,000
Purchase of electric energy	4,300
Earnings before Interest	**148.000**
Internal Return Rate (IRR)	**8%**
Capital Cost	**59.000**
Total Earnings	**89.000**

2. Biogas Case Study: BC Naklo

Gorenjska (in the picture below No 9) is the most Alpine of all Slovenian regions is situated in the north-western part of the country. Unlike Dolenjska, economically, Gorenjska is one of the most developed regions in Slovenia. Its prosperity is based on a well developed industrial tradition, dating back to the 19th century when it developed from ironworks and shoemaking which were very important at that time. Tourism in Bled, Kranjska Gora and Bohinj, and agriculture on the plains and in the surrounding mountains are also of significance.



Agriculture in the region is oriented towards dairy and beef cattle farming. The farmers producing on arable land mainly silage corn for fodder, cereals (wheat and barley) and potatoes. 51% of farms have less than 5 hectares of agricultural land. This agricultural structure is therefore favourable for biogas production, although in smaller scale. This is also exactly the result of study on potential for biogas production from agriculture in Slovenia commissioned by HSE (Holding Slovenske elektrarne). Namely Gorenjska is marked as one of the most suitable for such installations. The other suitable regions (mostly in the eastern part) are being already addressed therefore Gorenjska made quite an obvious choice.

Biotechnical centre Naklo is located near the main town Kranj. In the case of Biotechnical centre Naklo figures are much lower as here is not that much about farming production than it is about farming learning. Furthermore at BC Naklo a sustainable way of eco-farming is used. The biomass available is both cattle manure and green biomass. The quantities are quite small though. It was estimated that farm on its own is able to produce enough input for about 100 kW biogas CHP production unit and double that if input from the surroundings is taken into account.

Aerial view of Biotechnical centre Naklo

This option however, in spite of the interest of the farmers expressed, is for the time being not considered, as the use of their feedstock could compromise the farm eco-status, which they obviously do not want to jeopardize. The new supporting scheme for electricity production from RES (introduced in autumn 2009) is now offering additional bonus for feed-in tariffs for the electricity production from smaller biogas plants (< 200kWe) when using a certain (>30%) or prevailing part (>70%) of manure as a feedstock. Since BC Naklo is an educational institution and they are also becoming a research RES centre – in 2007 they installed at the time the biggest PV plant in Slovenia, they are going to use biomass for heating – and they are quite close to Kranj and Ljubljana as well, they form a natural choice for biogas/RES events or seminar venue especially for farmers but also for others.

Ortophoto of Biotechnical Centre Naklo with sourroudings

To use the digestate as a fertilizer – estimated production of 10 t per day - should not be a problem since the centre has its own fields and lies among them (look at the picture above) and there is also enough room for the digestate container. Should surpluses occur there should not be a problem to storage them and sell them as a fertilizer to neighboring farmers, especially because of the eco-farming and hence pure – uncontaminated fertilizer.

The utility company Gorenjske elektrarne is already investigating about possibilities of biogas plants in Gorenjska region and they already installed the PV plant at BC Naklo. They also want to take active part in the RES research centre. There is also no problem with the connection to the electricity grid and they already have the experience and know the necessary procedure in order to attain the declaration of the plant if to profit from the feed-in support scheme.

2.1. Basic plant design

Biomass and biogas potential

Manure used for digestion is all produced on spot. The most probable plant type is a co-digestion one which besides the manure could make use also of green biomass growing on the farm. The final execution depends on the final arrangements, which were not done yet.

The gas potential is calculated by means of the BiG East calculation model. Based on the estimations of the feedstock availability in the area the following biogas production calculation is shown below.

Klinja vas			**Biogas production**
Input	t /a	% DM	m^3 /a
Cattle manure	3200	10	
Maize silage	560	32	
Grass silage	880	40	
Total	4600		400.000

The amount of feedstock used in the calculation is based on the BC Naklo data. The biogas produced by digestion would be utilised in a combined heat and power unit and the electricity generated sold (feed-in) and supplied into the electricity grid. Heat would be used for heating the premises.

Utilisation of the biogas

The total amount of biogas production is approx. 400.000 m^3 (installed capacity around 100 kWe). In this case the biogas would be utilised in a CHP unit with gas engine and generator for the production of electricity for sale into the grid (feed-in tariffs) and for production of heat, which would be consumed on spot. The heat is mainly used for the process and heating of the premises. No external heat use is foreseen. The following energy production can be expected:

Energy production			
Biogas production engine capacity	2.253.000 kWh/a 103 kWe	at	6,00 kWh/m3 biogas
Utilisation			
Electricity production Total electricity production	901.000 kWh/a 856.000 kWh/a	at and	40% efficiency 5% of the time out
Heat production Used in the process For other use	1.036.000 kWh/a 570.000 kWh/a 466.000 kWh/a	at at	46% efficiency 38° C

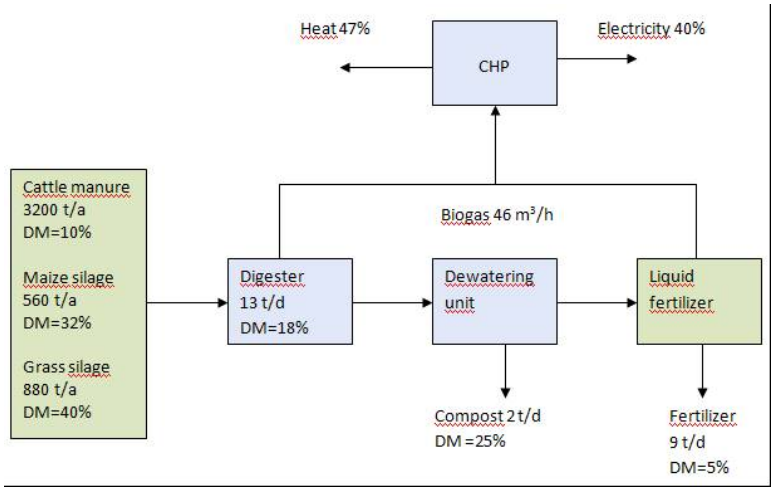
Calculated electricity production of approx. 901 MWh per year can be expected. Smaller part of the electricity produced is used for the plant operation (pumps, mixers, blowers etc.). This is estimated to approx. 60 MWh (equal to approx. 6,5% of the total electricity production). Which means approx. 840 MWh is left for the sale to the grid. It is expected that the engine is out of operation for servicing in approx. 5% of the time of the year. During service the gas is burned in a boiler for producing heat for the plant and possible surplus gas is flared off.

Biogas Digestate Utilisation

According to the nitrate directive the raw manure produced on farm and used for biogas production would require approx. 18 ha. Farm has a bit less than 23 ha of their ownfields, which means they are self sufficient. The requirement after digestion and separation will be lower because nitrogen is removed in the fibre fraction. The solid fertiliser (the fibre fraction) could be used on the farm and if any surpluses sold to the neighbouring farmers.

Flow chart

The mass balance of the biogas plant BC Naklo is quite simple. It is assumed that the digestate is separated in a liquid fraction and a solid one in order to reach higher utilisation of the nutrients. The feedstock input taken into account is cattle manure and green biomass (grass and maize silage).



1.2. Technology Specifications

The feedstock planned is cattle manure and green biomass regarded as suitable for mezzophilic digestion at 36°C and a retention time in the primary digester of app. 35 days.

Overall plant set up

The manure as well as the biomass is produced on the farm itself. This means transport and logistic required are minimal and are mainly related to the out taking of the digestate. The plant is provided with the reception tank, silage storage, prime and secondary digester and final storage tank. By an estimated retention time of approx. 35 days in the primary digesters the volume of the primary digesters will be approx. 300 m^3. For easy mixing of the feedstock and to save space digesters are foreseen as concrete insulated silos with internal heating pipes system and that they are provided with top mounted mixers. On the other hand secondary digesters can be made from a non insulated concrete tanks provided with a double membrane. The digestate is to be used as fertiliser and supplied/available to neighbouring farms and for farm own purposes. A buffer tank of around 500 m^3 is included on the site for the purpose.

1.3. Economical specifications

Investment

Based on the plant design (inputs and outputs) and technological solution which are described above the estimated costs are shown below. Biogas project tend to be financially demanding. In case of the project BC naklo it was taken into account that future operator and owner of the plant has very low experience on the subject and that the biogas plant would serve also for study and research purposes. Based on the above mentioned facilities and plant design the investments costs for such a plant are as follows:

Investment Cost: Project No 2 BC Naklo	**Euro**
Planning, engineering, commissioning etc	65,000
Equipment, machinery	190,000
CHP engine etc.	150,000
Construction, Buildings	240,000
Electrical equipment	55,000
Other costs	70,000
Total	**770,000**

Profit and Loss

For the assessment and the basic economic calculation the BiG East calculation model was used. Thus getting the preliminary estimation of costs, plant size, technical outline etc. The calculation model, as well as the guidelines for its utilisation, are freely available to download at www.big-east.eu. The main results obtained for the show case Klinja vas in summarised way is given in the table below:

Profit and Loss: Show Case No2 BC Naklo	**Euro/a**
Economic Yield from Plant Operation	
Yield from electricity sale	138,000
Plant working costs	
General Busines Cost	102,000
Purchase of electric energy	3,200
Earnings before Interest	**104.000**
Internal Return Rate (IRR)	**7%**
Capital Cost	**67.600**
Total Earnings	**36.800**

3. Organizational structure and Risk Management

The basic organisational structure and risk management are similar for both projects show cases. The owner of the plant are in both cases also the investor and operator of the plant. There are more options for the financing of he such projects in Slovenia. If state grants or soft loans are used than the feed-in tariff get lowered accordingly. In principle the ownership has to be defined and the agreement between the plant owner and the ones dealing with the plant has to be structured. Important is to set up the organisation in a sense that the ones that have an influence on normal operation also take the risk and gain the advantages.

3.1. Construction

It is assumed that the plant is constructed by local contractors in relation to an engineering project/specification and a split tender in more packages. The engineering can be partly based on already built plants in Slovenia, however because of a lack of smaller plants also the foreign experiences shoul be taken into account. The advantages of taking in local contractors are possible low prices, advantages for local economy and easier later service and possible rebuilding. For the construction control a local site manager is recommended.

3.2. Feedstock providers

The feedstock is in both cases provided in house and therefore no agreement and contracts are needed in this regard

3.3. Risk Management

Both projects would mean positive effect for the local agriculture and the local environment. The BC project can also be a positive show case for development of smaller biogas plants in Slovenia.

The main economic profit comes in both examples from electricity selling. In the second case there are also secondary benefits in terms of educational, study and research facility. Since both location are owned by the investors and there is room enough for plant construction there are no constraints in this regards.

As it can be seen both projects can be economically vaiable provided that the planning and operation of the plant is ok. When the finance and the overall organisation is agreed the overall clarifications can be made step by step detailing of the project included. For detailed assessment of the projects more detailed feasibility study/action plan should be made.